Utilizing Unused Resources To Improve Checkpoint Performance

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Filesystem Performance

- Users want faster I/O
- Less performance variability would be nice, too
- Mostly write performance (not a lot of reads happening)
- I/O patterns are fairly ‘bursty’ – lots of time between writes
Measuring delivered compute-hours, GPU usage was around 50% in 2014.

Why aren’t all apps using the GPU?
- Some good reasons, some not-so-good reasons

“Why” isn’t particularly important. What’s important is that there’s some unused hardware on the nodes. Maybe we can do something interesting/useful with it.

Let’s use the GPU memory to cache filesystem writes.
How does all this work?
1. Send Write Request

- User
  - MPI Process
  - I/O Daemon

- Kernel
  - Page Cache

- Hardware
  - NIC
  - GPU
2. Allocate GPU Memory, convert pointer to handle
3. Send Reply with Handle

User
- MPI Process
- I/O Daemon

Kernel
- Page Cache

Hardware
- NIC
- GPU

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4. Write to GPU Memory

- MPI Process
- I/O Daemon
- Page Cache
- NIC
- GPU
5. Send Write Ready

- User
  - MPI Process
  - Page Cache

- Kernel
  - Page Cache

- Hardware
  - NIC
  - GPU
6. Read from GPU Memory to Daemon Memory

- User:
  - MPI Process
  - Page Cache

- Kernel:
  - NIC

- Hardware:
  - GPU

- I/O Daemon
7. Write to Page Cache/PFS
Basic Performance Statistics

Writing to the filesystem
- 8 ranks/node, each rank writes to separate file
- Nothing fancy – just calling write()
- 550 MB/sec/rank to cache - 100 MB/sec/rank to the filesystem
- Max write size that fit in cache: 256MB / rank

Writing to the GPU memory
- NVidia’s bandwidth util says compute nodes can write about 5.5GB/s into GPU memory
- Our observed aggregate BW was somewhat less, but still much better than writing to the filesystem
- 550 – 650 MB/sec/rank up to 512MB size
Basic Performance Statistics - Filesystem

Average Per-Rank Bandwidth vs. Write Size (8 Ranks/Node)

Bandwidth (MB/s) vs. Write size (MB)
Is it worth the effort?

- Much faster than writing straight to the filesystem
- It appears to be a little faster than writing to the Lustre client-side cache
  - Lustre client-side cache needs system memory, which might not be available
- Performance variability should be decreased
  - This is conjecture – trying to get variability numbers is tricky, and it’s questionable whether numbers obtained from a synthetic benchmark would be useable anyway.
- Similar improvements with 16 ranks/node
  - Cores are oversubscribed, though
Caveats, Potential Pitfalls

- Data hasn’t made it to permanent storage
  - Don’t immediate delete your last checkpoint file

- Write only
  - Reads will return what’s in the file, not what’s in GPU memory
  - No way to verify if a particular write has made it out to the filesystem

- Applications running 16 ranks/node would have to oversubscribe cores to run the daemon
  - For some applications, this might still be a net improvement
Next Steps

- Looking at ways to make this available in a production environment

- We want something that will require minimal modifications to existing code.

- Looking writing a library that will replace existing POSIX calls (open(), write(), etc…) with our own versions
  - Similar to how the MercuryPosix project works

- Also considering modifying existing I/O libraries such as NetCDF.
  - Maintaining the modified libraries might be too much work, though
Conclusions

- Don’t use this technique – port your code
  - Far better to use the GPU hardware for what it was designed: calculations

- If and **ONLY IF** you can’t port your code, then this technique offers some benefits

- Don’t immediately delete your checkpoint file
Questions?

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